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Artificial Intelligence in Gastrointestinal Endoscopy

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ABOUT COVER

Associate Editor of *Artificial Intelligence in Gastrointestinal Endoscopy*, Peter Bauerfeind, MD, Professor, Department of Gastroenterology and Hepatology, University hospital Zurich, Zurich 8091, Switzerland.
peter.bauerfeind@usz.ch

AIMS AND SCOPE

The primary aim of *Artificial Intelligence in Gastrointestinal Endoscopy* (AIGE, *Artif Intell Gastrointest Endosc*) is to provide scholars and readers from various fields of artificial intelligence in gastrointestinal endoscopy with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

AIGE mainly publishes articles reporting research results obtained in the field of artificial intelligence in gastrointestinal endoscopy and covering a wide range of topics, including artificial intelligence in capsule endoscopy, colonoscopy, double-balloon enteroscopy, duodenoscopy, endoscopic retrograde cholangio-pancreatography, endosonography, esophagoscopy, gastrointestinal endoscopy, gastroscopy, laparoscopy, natural orifice endoscopic surgery, proctoscopy, and sigmoidoscopy.

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Robotic surgery in colon cancer: current evidence and future perspectives – narrative review

Fulvio Tagliabue, Morena Burati, Marco Chiarelli, Ugo Cioffi, Mauro Zago

ORCID number: Fulvio Tagliabue 0000-0002-4095-017X; Morena Burati 0000-0003-2562-4760; Marco Chiarelli 0000-0003-1729-4925; Ugo Cioffi 0000-0002-5321-5828; Mauro Zago 0000-0001-9322-0798.

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Fulvio Tagliabue, Morena Burati, Marco Chiarelli, Mauro Zago, Department of Emergency and Robotic Surgery, A. Manzoni Hospital–ASST Lecco, Lecco 23900, Italy

Ugo Cioffi, Department of Surgery, University of Milan, Milano 20122, Italy

Corresponding author: Ugo Cioffi, MD, PhD, Full Professor, Professor, Surgeon, Department of Surgery, University of Milan, Via F. Sforza 35, Milano 20122, Italy. ugocioffi5@gmail.com

Abstract

In the last 10 years, surgery has been developing towards minimal invasiveness; therefore, robotic surgery represents the consequent evolution of laparoscopic surgery. Worldwide, surgeons' performances have been upgraded by the ergonomic developments of robotic systems, leading to several benefits for patients. The introduction into the market of the new Da Vinci Xi system has made it possible to perform all types of surgery on the colon, an in selected cases, to combine interventions in other organs or viscera at the same time. Optimization of the suprapubic surgical approach may shorten the length of hospital stay for patients who undergo robotic colonic resection. From this perspective, single-port robotic colectomy, has reduced the number of robotic ports needed, allowing a better anesthetic outcome and faster recovery. The introduction on the market of new surgical robotic systems from multiple manufacturers is bound to change the landscape of robotic surgery and yield high-quality surgical outcomes.

Key Words: Colon cancer; Robotic surgery; Colectomy; Laparoscopy; Surgical outcomes: Robot system

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Core Tip: Robotic surgery represents the natural evolution of laparoscopic surgery in the way to perform less-invasive operations. The robotic system Da Vinci Xi® with its technological innovations has made it possible to perform all types of interventions on the colon and has yielded large benefits to patients.

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INTRODUCTION

Cancer of the colon and rectum is one of the most common neoplastic diseases worldwide and is associated with high mortality rate[1]. Just as laparoscopic surgery has progressively replaced laparotomy, robotic surgery is becoming increasingly important in the treatment of this type of cancer. The advantages of robotic systems have been well known for years. Wrist flexibility, 3D vision and prevention of hand tremor enable surgeons to operate in reduced operative fields.

Many technological innovations have been introduced in recent years, such as a suprapubic approach, single port techniques and the use of tracers such as indocyanine green (used for the research of the sentinel lymph node and to verify tissues' vascularization).

The efficiency and effectiveness of robotic colonic resection have drawn the attention of many surgeons. Just as laparoscopic surgery in the late 1990s was compared to open surgery in terms of safety and effectiveness, nowadays robot-assisted surgery is often compared to the laparoscopic approach. From this point of view, robotic surgery seems to overcome the limits of laparoscopy. In fact, the proper value of the robot can be clearly appreciated in challenging tasks, such as performing intra-abdominal anastomoses in a restricted space, or in low pelvic dissection[2].

Although early results seem to encourage robot-assisted surgery, comparative studies investigating the effects of laparoscopic *versus* robotic colonic surgery are still ongoing and have not yet provided definitive data[3,4].

ROBOTIC VERSUS LAPAROSCOPY

The indications for robot-assisted and laparoscopic colorectal surgery are the same. Relative contraindications are emergency procedures, pneumoperitoneum intolerance and massive bleeding.

Comparison between robotic and laparoscopic surgery in terms of advantages and disadvantages has been considered a "hot topic" lately. Detractors of robotic surgery doubt its effective usefulness, citing the lack of definitive data demonstrating its superiority compared to the traditional laparoscopic approach[5] (many have stated that it is an "expensive toy" built to entertain surgeons). Nevertheless, increasing data about the effectiveness of robot-assisted surgery, in addition to its well-described technical advantages, have drawn the attention of surgeons all over the world.

Since the da Vinci System has been approved, an increasing number of robotic procedures has been registered worldwide. As a consequence, available data on robotics in colorectal surgery have increased greatly. In the international scientific literature, single- and multicenter studies, systemic reviews and meta-analyses can be easily found, focusing on the evaluation of robotic outcomes[6]. Two National Impatient Sample databases of laparoscopic and robotic colectomies[7,8] found no significant differences in overall complication rates and length of stay, while conversion rates were significantly lower in patients who underwent robotic resection (6.3% *vs* 10.5 %). One large study, based on the American College of Surgeons National Surgical Quality Improvement Program database, compared robotic and laparoscopic colorectal surgery in more than 11000 patients[9]. Focusing on pelvic surgery, the rate of conversion to open approach was lower in the robotic surgery group, while no significant differences in conversion rates were found in abdominal surgery. No differences were found in rates of wound infection, anastomotic leak, 30-day reoperation and 30-day readmission. When robot-assisted surgery was performed, mean hospital stay was significantly shorter but operating times were significantly longer. The reason for longer operating time is easily imagined. Robotic surgery needs longer preparation in terms of patient and arm positioning, moreover, being a new technique, the learning curve of the performing surgeon strongly affects the overall operating time. In our opinion, this highlights the importance of continued evaluation of the advances in robot-assisted surgery compared to more traditional minimally invasive techniques.

A retrospective cohort study of the Michigan Surgical Quality Collaborative registry compared robotic *versus* 2735 laparoscopy-assisted colorectal procedures in 2012–2014 [10]. Conversion rates were lower in robotic surgery, and this was significant for rectal resection. Also, hospital stay was significantly shorter in those operated upon with the robotic technique. No significant difference in rates of complications were found.

In our opinion, the most meaningful, largest and better-designed study was the Robotic Versus Laparoscopic Resection for Rectal Cancer (ROLARR) Trial [11] published in 2017. It was an international, multicenter, randomized controlled trial (RCT), involving 10 countries and 29 centers. Primary outcome was conversion to open procedure when performing total mesorectal excision (TME). Intra- and postoperative complications, circumferential resection margin, quality of life, bladder and sexual dysfunction and oncological outcomes were considered secondary outcomes. The results showed no differences in conversion rates or other secondary endpoints, demonstrating that, in expert hands, robotic colonic resection is safe and feasible. What deserves to be highlighted is that, once again, robotic surgery did result in longer operating time. Only experienced surgeons were included in the study (surgeons who performed at least 90 laparoscopic or at least 50 robotic procedures), excluding the influence of the learning curve on operating time. Therefore, we can conclude that, more likely, robotic operating time is more affected by its longer patient preparation, and instrument placement and changing. In our opinion, it is important to highlight that conversion rates were lower in the robotic *versus* laparoscopic surgery in men. This suggests that, when it comes to narrower pelvis, robotic surgery could be superior to the laparoscopic approach, bringing great benefits to patients. The authors concluded that robotic surgery does not confer an advantage in rectal cancer and has equivalent outcomes with increased costs (due to the price of robotic instruments and components).

A meta-analysis of five RCTs in 2018 [12], including ROLARR, by Prete *et al* [12] compared laparoscopic *versus* robotic resection for rectal cancer. The results demonstrated no significant differences in circumferential radial margin positive rate, TME grade, postoperative leakage, number of lymph nodes harvested, mortality or complication rate. This meta-analysis highlighted that robotic procedures are connected to a decreased rate of conversion to open surgery but, at the same time, a significant increase in operating time.

Conversion rate is an important outcome that can influence other outcomes. The passage from minimally invasive to open surgery can influence postoperative complication rates. It can also be the cause of increased costs (due to longer hospital stay) and delays in chemotherapy, which can affect 5-year disease-free survival, leading to higher recurrence rates [9,13,14].

All the advantages and disadvantages of robotic surgery are summarized in the Table 1.

From the analysis of the literature, the following conclusions can be drawn regarding the different aspects taken into consideration.

Postoperative days until the first flatus and first oral diet

Robot-assisted colorectal surgery is associated with a shorter time to first flatus and to first oral intake [15–17].

Time of operation

The literature shows longer operating time for robotic surgery [15–20]. In most cases, the reason is probably related to the early learning phase of the surgeons. We believe that after an adequate learning curve, surgical times should be significantly reduced to be compared to laparoscopic surgery. Nevertheless, it is easy to imagine that overall operating time will be always slightly longer for robotic surgery due to longer time needed for patients' preparation and instrument placement and changing.

Length of hospital stay

The robotic approach had a shorter hospital stay in several studies [19–25].

Mortality (perioperative or 30 d after the operation)

A few studies have demonstrated that mortality rate is significantly reduced in robotic surgery [20–26], but, on the contrary, other systematic reviews and meta-analysis have not confirmed this result [16,21–23].

Conversion to open surgery

It has been demonstrated that, compared to laparoscopy, robotic surgery is associated

Table 1 Advantages and disadvantages of robotic surgery

Advantages	Disadvantages
High-resolution 3D view	Longer operating times due to patient preparation and positioning and docking time
Tool and wrist flexibility (seven degrees of freedom)	Lack of tactile sensation and stenic feedback
Elimination of hand tremors	High acquisition and maintenance cost
Ergonomic position which benefits the surgeon	
Faster learning curve	
Dual console and simulation software for training	
Integrated table motion	
Four trocars visualization with fluorescent/optical systems	
Robot-designed tools, like robotic stapler with smart-fire technology	

with a significantly lower rate of conversion to open surgery. This is more relevant in high-risk patients, such as men with a narrow pelvis, obese patients with lower rectal tumors, or those undergoing neoadjuvant therapy[13,16-23].

Intraoperative blood loss

In terms of blood loss, some studies have reported significantly lower rates in robotic surgery[17,18,20,24].

Anastomotic leakage

As far as we know, no significant differences regarding anastomotic leakage have been found in the literature. In our opinion, in the near future the introduction of new automatized stapling systems and new robotic technologies will reduce the rate of anastomotic leakage.

Resected lymph nodes

No differences have been reported in the number of lymph nodes resected using robotic *versus* laparoscopic surgery, although some studies have shown a higher number of harvested lymph nodes in the robotic approach[15].

Sexual and urological outcomes

Considering rectal cancer surgery, recovery of sexual and urological function is faster in patients who have undergone a robot-assisted approach compared to laparoscopic surgery. In one retrospective cohort study, rates of erectile dysfunction 1 mo after surgery were similar in both laparoscopic and robotic groups. However, 1 year after complete recovery, physiological functions were completely restored in all sexually active patients who underwent robotic resection and only in 43% of patients in the laparoscopic group[25-27].

Surgical wound infection

Review articles and clinical trials have not shown any significant difference between the robotic and laparoscopic groups for surgical wound infection. There is only one systematic review published in 2019 by Ng *et al*[16] that showed a significant difference in favor of the robotic approach. We believe that future technological innovation will allow an increasing number of full robotic procedures, and consequently, the size of the skin incisions will progressively reduce, therefore decreasing surgical wound infections.

Resection margins

Simillis *et al*[28] in a systematic review and network meta-analysis published in *Annals of Surgery* in 2019[28] demonstrated no significant differences regarding the involved resection margins. A study by Nixon *et al*[29] focusing on high-risk patients (preoperative chemoradiotherapy, male sex, tumor < 8 cm from the anal verge, body mass index > 30, and previous abdominal surgery) demonstrated that robotic surgery is related to higher rates of sphincter preservation, lower conversion rates, lower blood

loss and operating time, and consequently it is associated with shorter length of hospital stay.

THE PRESENT AND THE FUTURE

With advances in engineering and technology, surgical robots are constantly being improved. Exploration of new surgical approaches like the suprapubic approach or single port technique is of interest in the surgical field. The suprapubic surgical approach refers to a particular robotic technique in which ports used to perform colonic resection are placed in a horizontal line in the suprapubic area, and it is usually applied in robotic right colectomy. Recently, some authors have demonstrated[30,31] that the suprapubic approach has more advantages than the traditional port placement, with less console time and shorter hospital stay. Surgeons are attempting to reduce the number of ports used for robotic surgery. By reducing the number of surgical wounds, they aim to reduce the risk of postoperative wound infections. In this light, single port robotic surgery has begun to be performed more often. A systemic review[32] revealed that single port robotic surgery for colonic cancer is safe and feasible, with acceptable postoperative outcomes. These new changes have demonstrated promising potential in robotic surgery, in particular in colonic resection.

Until now, the surgical robot market has been monopolized, but it is easy to predict that the market for robotic platforms will rapidly grow in the near future as several manufactures are investing in the development of new robotic systems. For instance, MicroHand S is a robotic system produced in China and has recently entered clinical trials. Some studies have reported good performances and encouraging application prospects[33,34]. Senhance robotic system (TransEnterix Surgical Inc. Morrisville, NC, USA) has been recently introduced in Europe and approved for limited clinical use in the USA. Darwich *et al*[35] and Samalavicius *et al*[36] reported that procedures performed with this robotic system were safe and feasible and the robot could be used in general surgery. Versius from Cambridge Medical Robotics Ltd (Cambridge, UK), Hugo RAS from Medtronic Inc. (Dublin, Ireland), Meere Company (South Korea), Titan Medical (Toronto ON, Canada) and Virtual Incision (Pleasanton, CA, USA) have demonstrated potential in clinical applications. Competition between these new surgical robots from different manufacturers will surely change the market, leading to a reduction in costs with increased benefits for patients.

CONCLUSION

Robotic surgery offers a new minimally invasive approach in complex procedures or in anatomical areas that are difficult to reach. Robot-assisted procedures are not easier to perform, but robotic technology can make hard tasks feasible for less-experienced surgeons. In our opinion, robotic surgery could be considered the best option for rectal cancer surgical treatment, especially when compared to more traditional approaches (laparoscopic, open or transanal), since it offers the best combination of oncological, functional and patient recovery outcomes. Furthermore, the development of new approaches, like suprapubic and single port techniques, and the use of new devices, like the robotic stapler or vessels and lymph nodes tracers, will allow us to reach better results in oncological and clinical terms. The introduction of new surgical robots from multiple different suppliers will reduce their cost, leading to the widespread of the robot-assisted approach for colonic resection.

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